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Serious gaming technology in major incident triage training: A pragmatic controlled trial

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## Abstract

**Objective:** By exploiting video games technology, serious games strive to deliver affordable, accessible and usable interactive virtual worlds, supporting applications in training, education, marketing and design. The aim of the present study was to evaluate the effectiveness of such a serious game in the teaching of major incident triage by comparing it with traditional training methods.

**Design:** Pragmatic Controlled Trial

**Method:** During Major Incident Medical Management and Support Courses, 91 learners were randomly distributed into one of two training groups: 44 participants practiced triage sieve protocol using a card-sort exercise, whilst the remaining 47 participants used a serious game. Following the training sessions, each participant undertook an evaluation exercise, whereby they were required to triage 8 casualties in a simulated live exercise. Performance was assessed in terms of tagging accuracy (assigning the correct triage tag to the casualty), step accuracy (following correct procedure) and time taken to triage all casualties. Additionally, the usability of both the card-sort exercise and video game were measured using a questionnaire.

**Results:** Tagging accuracy by participants who underwent the serious game training was significantly higher than those who undertook the card sort exercise [ $\chi^2 = 13.126$ ,  $p=0.02$ ]. Step accuracy was also higher in the serious game group but only for the numbers of participants that followed correct procedure when triaging all 8 casualties [ $\chi^2 = 5.45$ ,  $p=0.0196$ ]. There was no significant difference in time to triage all casualties (card-sort =  $435 \pm 74$  vs video game =  $456 \pm 62$  seconds,  $p=0.155$ ).

**Conclusion:** Serious game technologies offer the potential to enhance learning and improve subsequent performance when compared to traditional educational methods.

**Comment [SJ1]:** Is it worth mentioning that this will be covered in another paper, as the reader may wonder why it is not discussed further in this paper?

## Introduction

When the clinical needs of a group of patients exceed available resources, swift and effective prioritisation of treatment is critical in ensuring the best possible outcome. The implementation and execution of triage processes by first-responders is fundamental in ensuring such prioritisation is performed rapidly and accurately, and thus central to the successful management of major incidents.

One commonly used method for conducting triage is the Triage Sieve, as taught on the Major Incident Medical Management and Support Course (MIMMS) (1-3). This method uses a combination of mobility and physiological assessment to quickly assign a patient an initial four-state priority ranking, based on respiratory rate, capillary refill, and visual inspection.

Traditionally Triage Sieve processes are taught in small practical workshops, where learners are introduced to the system as a group and then each have 10-15 minutes with an instructor to practise the assessment on mock patients, either in the form of mannequins or live models placed in a classroom setting. Practical restrictions often limit the degree to which the activities undertaken during training reflect the real-world conditions under which triage situations are likely to arise, as well as the accuracy and realism with which injury and patient deterioration occurs. Although large-scale real-world training events can create plausible environments, these require significant amounts of resources, do not allow learners to easily repeat activities, and are unable to structure the learning experience around the individual.

Synthetic environments offer a potential solution to many of these issues. Whilst pure simulations may create authentic environments, they frequently lack the ability to motivate and engage learners. The introduction of game elements within simulations, to produce serious games (games used for non-leisure purposes), has been shown to be beneficial in training scenarios where rapid execution of process based knowledge is key (4). These approaches utilise the skills and experience of games developers to achieve engaging learning environments which include both technical and conceptual elements from entertainment games. Players are intended to learn as they play, experimenting, failing and succeeding as they would in entertainment games. Through playing the game they learn which strategies are successful, and thus become more skilled. Major incident training, with the need to replicate a learning environment that cannot be achieved in the real world, is an obvious area in which to design and test the ability of serious games to deliver effective learning in healthcare. We therefore sought to design, build and test a serious game to assist in the education of trainees in major incident management.

The Triage Trainer was designed to allow learners to play through a major incident scenario, triaging casualties as and when they discover them. The prototype, which may be deployed on a PC or laptop using a mouse to navigate, has been developed to enable learners to practice and experience the triage sieve process. It provides a training scenario where a bomb has just exploded in a busy urban street; the scene shows the expected infrastructural destruction along with a number of casualties located around the scene. The trainee is advised that they are the first responder at the scene, told that the scene is safe to enter, and tasked with tagging each casualty with the appropriate priority.

Navigation to a casualty is performed by a point and click process using a computer mouse or laptop touchpad. Once at a casualty the trainee can assess the status of the casualty by clicking icons to perform the appropriate medical checks (figure 1).

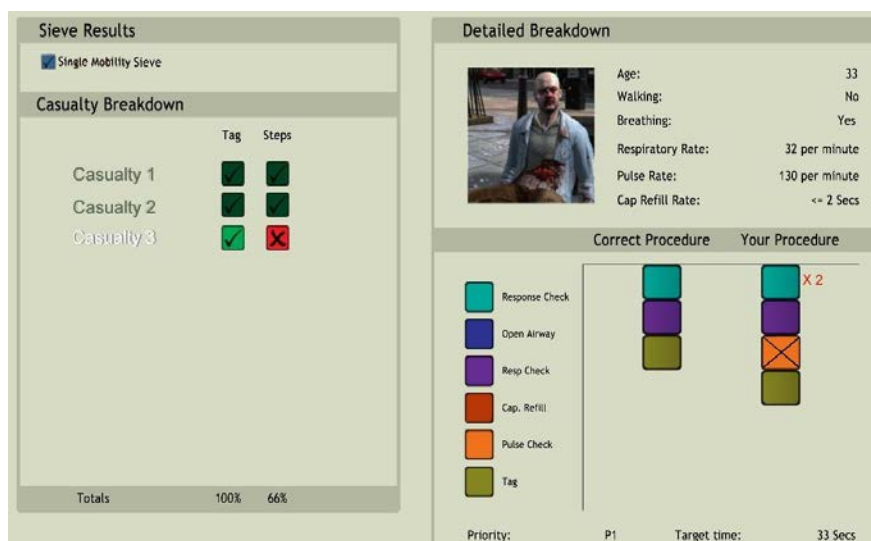
Figure 1: Triage Trainer casualty status checks



Once the necessary checks have been made, the trainee assigns the priority using the Priority icon. Once tagged, the trainee continues onto other casualties. Each scenario comprises three to ten casualties.

When all casualties in the scene have been prioritised, the trainee is presented with an after action review (AAR) (figure 2). The left side of the AAR allows the trainee to examine their accuracy on tagging and following the correct steps for assessment for each casualty. In addition an overall percentage score for both tags and steps is given. On the right side of the AAR, a more focused level of feedback is presented, in terms of a breakdown of performance for each casualty, which indicates how and where mistakes were made.

Figure 2. The Triage Trainer After Action Review (AAR) screen



A demonstration of Triage Trainer in action can be found online at <http://www.trusim.com/?page=Demonstrations>.

The aim of this study was to evaluate the effectiveness of this serious game (Triage Trainer) in supporting the teaching and development of basic major incident triage skills. The objective was to compare triage performance after practicing the triage process using the Triage Trainer or by other, more traditional learning methods.

#### Methods

The prototype serious game Triage Trainer was evaluated using participants who attended four MIMMS courses in the United Kingdom between October 2007 and January 2008. MIMMS courses are run by the Advanced Life Support Group. They are aimed at clinicians who may be required to attend the scene of a major incident. Triage is one aspect of the course. Participants typically include doctors, nurses and paramedics with an interest in pre-hospital care.

#### Participants

During the courses 91 attendees gave informed consent to participate in the study. On the MIMMS course participants are allocated to one of four groups by the course co-ordinator. For the purposes of this study, and prior to the commencement of the course, the co-ordinator assigned half of these groups to experience triage using Triage Trainer and half to a standard small group card-sorting exercise led by a MIMMS course instructor. Participant details for each group are shown in Table 1.

Table 1. Participant details. Parenthesised data shows frequency count as a percentage of the group

		Card sort ( n = 44)	Triage trainer (n = 47)
Age	20-29	6 (14%)	4 (9%)
	30-39	18 (41%)	26 (55%)

	40+	10 (23%)	14 (30%)
	Missing data	10 (23%)	3 (6%)
Sex	Male	30 (68%)	31 (66%)
	Female	10 (23%)	16 (34%)
	Missing data	4 (9%)	0

Before undertaking the Triage Trainer or Card-sort exercises all participants had been involved in a face-to-face lecture on triage methodologies. Triage was also an integral element of the pre-course reading material. This meant that all participants had been exposed to, or presented with, the appropriate information to complete the card-sort and Triage Trainer exercises.

#### Exercise Conditions

In the Triage Trainer group, participants were given an initial 15-minute tutorial on gameplay procedure followed by a gameplay period of 60 minutes. During the activity, the participants were able to ask for assistance if required. The small workshop group were tasked to document patient priorities on cards based on written physiological and mobility findings. The participants continued this exercise for 60 minutes. Card sort participants were denied access to the game. Both groups were given feedback on their performance either through the game or through instructor feedback in the card-sort group. Participants in the card-sort group were given feedback and were able to ask questions during the training workshop.

Following the practice exercises triage ability was assessed in a simulated mass casualty situation. This took place 2-3 hours after learning had taken place. The assessment exercise used a mock-up scenario of a domestic outdoor gas explosion accident and used 8 local actors who simulated a range of injuries. The actors were all located in a single room and took up positions associated with their injuries. On entering the room one at a time, the participants were required to triage sieve the 8 casualties and assign each of them a priority tag. The actors were all made up appropriately and external injuries were therefore visible. Additional information was available to the participants both from the actors (if appropriate to their injuries and using prepared scripts) and from one accompanying assessor who could supply necessary physiological values in real time when appropriately prompted. A second assessor recorded the order in which checks were made and the priority tag allocated. The assessors were instructors on the course and were therefore not blinded to the student allocation. No assessor was associated with the Triage Trainer in any way.

Each scenario was videoed to confirm the accuracy of the records - this was subject to the written agreement of the participant. On completing the assessment exercise, participants were kept separate from those who were awaiting assessment.

#### Measures

The primary outcome measures were performance in an assessment exercise based on Tagging accuracy (proportion of correctly tagged casualties); Step accuracy, in terms of following the procedure correctly; and the time taken to triage all 8 casualties.

#### Statistics

Chi Squared analysis was used to assess the affect of exercise condition on Tagging accuracy and Step accuracy variables. The effect of exercise condition on overall time to triage all casualties was assessed using Students t-test. Statistical analysis was performed using SPSS 15.0. Significance was set at the  $p < 0.05$  level.

#### Ethics

The local ethics committee was contacted to determine the need for formal ethics submission. We were advised that formal ethical approval was not required as the study was considered a service evaluation project. Written informed consent was still obtained from all participants before they took part in the trial.

#### Results

##### Tagging accuracy

Table 2 shows tagging accuracy and step accuracy as a frequency count of the numbers of participants who triaged the number of casualties correctly; those that triaged one casualty correctly and so on up to those that correctly triaged all eight casualties. With more participants scoring 8/8 and fewer scoring 7/8, 6/8 and 5/8 in the Triage Trainer group, table 2 shows that the Triage Trainer group performed significantly better than the card-sort group [Chi = 13.136, df = 5,  $p = 0.02$ ] for Tagging accuracy.

Table 2. Triaging performance. Absolute frequencies (as percentage of the group)

No. of casualties correctly triaged	Tagging Accuracy (%)		Step Accuracy (%)	
	Card sort small group	Triage Trainer group	Card sort small group	Triage Trainer group
0/8	0 (0)	0 (0)	2 (5)	2 (4)
1/8	0 (0)	0 (0)	2 (5)	3 (6)
2/8	1 (2)	0 (0)	5 (11)	0 (0)
3/8	0 (0)	0 (0)	3 (7)	2 (4)
4/8	0 (0)	2 (4)	8 (18)	7 (15)
5/8	3 (7)	2 (4)	8 (18)	9 (19)
6/8	5 (11)	0 (0)	6 (14)	6 (13)
7/8	11 (25)	9 (19)	7 (16)	5 (11)
8/8	24 (55)	34 (72)	3 (7)	13 (28)

NB. Numbers in brackets may not add up to 100 due to rounding off

##### Step accuracy

In the card-sort group 57% of the casualties were triaged without a step error. In the Triage Trainer group 68% of the casualties were triaged without a step error. Chi squared analysis using the Likelihood ratio shows that there was no significant difference between the card-sort and Triage Trainer groups for the numbers of participants across all eight accuracy groups ( $p > 0.05$ ). However, four times as many participants correctly triaged all eight casualties in the Triage Trainer group than the card-sort group. The number of participants that achieved an 8/8 accuracy score (card-sort = 7%, Triage Trainer = 28%) can be compared with those who attained an accuracy score of less than eight correctly triaged casualties out of



eight (card-sort = 93%, Triage Trainer = 72%). Using Chi squared analysis with Yates correction for a 2x2 contingency table shows that the Triage Trainer group had significantly more participants scoring the maximum than the card-sort group [Chi = 5.450, df = 1, p=0.0196].

#### Time

There was no significant difference in the time taken to triage all eight casualties in the card-sort group (435±74 seconds) and the Triage Trainer group (456±62 seconds) (t-test. p=0.155)

#### Discussion

This study has shown that students taught using the serious gaming method are significantly more likely to accurately triage all the casualties using the Triage Sieve. This is an encouraging finding, but further research is needed to determine how best to utilise gaming technology in medical education. Further, it is difficult to state categorically that this statistically significant improvement can be translated into better patient outcomes, especially as the whole concept of triage is not firmly evidence-based and is little researched (5). However triage is widely accepted and it makes sense that increased methodological accuracy is desirable.

Comment [SJ2]: Punctuation issue here

The proximity of the training to the assessment exercise may lead to an increased level of performance for all participants. While there is some evidence to suggest that immersive simulation and games improve retention over other training methods (6) future studies should look at the ability of learners to retain their triage skills over a prolonged period of time.

A major strength of the study conducted was its evaluation through integration into the MIMMS course, an internationally established course that places great emphasis on triage. By demonstrating effective learning using game based technology within the MIMMS course, this study has shown a pragmatic comparison of a game-based approach to an established training method, as opposed to an isolated evaluation against a novel learning task. Through this study, we have shown that gaming technology can integrate effectively into existing courses. Many short knowledge and skills courses (such as Advanced Paediatric Life Support (7)) are now using elements of e-learning to supplement the face-to-face components of their courses, and foresee future developments in the application of gaming technology to facilitate increasingly remote and independent learning. Whilst there is a great deal of interest in the use of serious games in military and commercial settings, there are few empirical studies focused upon game-based learning within healthcare.

More generally, this study contributes towards an understanding of the issues surrounding the use of serious games in healthcare education, and the factors influencing their efficacy. Entertainment gaming constitutes a genre of software in which the users affective experience is paramount (8); the entertainment elements and familiar interaction styles which are inherent to entertainment games are also applicable in serious game development. One of the things that we observed of the participants playing the game was how engrossed and immersed they were, and this came through in the qualitative feedback they provided. Triage Trainer has therefore shown the value of the use of leisure game assets, technologies, and development expertise in the creation of a serious games in healthcare. The user feedback

Comment [SJ3]: Suggest deleting "a"

from the first pilot trial identified issues with the game that needed addressing, such as the complexity of the feedback in the game. We had involved medical and training SMEs and the user community in the design of the game, but the feedback from the pilot trial exposed the need for even greater SME and user involvement earlier in the development process(9)-.

This study has shown the potential for the use of a serious game within one specific application area in medical education. Triage is a skill that is needed in many different environments such as military operations, and a game-based system provides the ability to learn, practise and assess this skill in ways that are not easily achieved with traditional methods.

#### Conclusion

This study has demonstrated that serious gaming technology can be used to teach major incident triage, that it improves the accuracy of the triage process when this process is assessed immediately after training and suggests that it may have a role to play in the ~~future~~ future if these promising early results are maintained.

#### Conflicts of interest

Richard Smithies is an employee of Blitz Games Studios Limited, and Steve Jarvis and Bryan Tregunna are employees of SELEX Systems Integration Ltd. These two commercial companies co-funded the project with the UK governments Technology Strategy Board.

#### Acknowledgements

We would like to acknowledge the contribution of Dr Daniela Romano from the University of Sheffield to the trial design. We are also very grateful for the support given by Advanced Life Support Group in this research.

#### Funding and affiliations

The game was developed by TruSim, a division of Blitz Games Studios Limited; with instructional design input by SELEX Systems Integration Ltd (formerly VEGA Group plc) and human factors experts from the University of Birmingham, and a leading expert in game-based learning from Coventry University. This project was co-funded by the UK governments Technology Strategy Board's Collaborative Research and Development programme, following an open competition.

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